YMP	**Model Error Resolution Document** *Complete only applicable items.*	QA: QA Page 1 of 9

INITIATION

1. Originator: Kenneth Rehfeldt	2. Date: April 7, 2008	3. ERD No. MDL-NBS-HS-000006 ERD 01
4. Document Identifier: MDL-NBS-HS-000006 REV 03 AD 01	5. Document Title: UZ FLOW MODELS AND SUBMODELS	

6. Description of and Justification for Change (Identify applicable CRs and TBVs):

INTRODUCTION

This ERD addresses TBVs associated with *UZ Flow Models and Submodels* (MDL-NBS-HS-000006 REV03 AD01), as listed below:

- **TBV-8672**
- **TBV-8685**
- **TBV-8687**.

Changes related to these TBVs are presented in the attachment to this ERD. The most recent version of the report is MDL-NBS-HS-000006 REV 03 AD 01 (which includes ACN 01), but none of the changes identified in this ERD will impact the ACN 01 portion of that document. Changes are being made to the version MDL-NBS-HS-000006 REV 03 AD 01 because that version is the most recent that is impacted by the changes resulting from the TBVs and includes the parent report MDL-NBS-HS-000006 REV 03.

CONCURRENCE

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7. Checker	Clifford Ho	Clifford K. Ho	4/10/08
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APPROVAL			
9. Originator	Kenneth Rehfeldt	Kenneth Rehfeldt	4/10/08
10. Responsible Manager	Paul Dixon	Paul	4-10-08

I. Background Information Summary

TBV-8672: The version of the FEP DTN: MO0706SPAFEPLA.001 [DIRS 181613] cited in the document was an early version that was subsequently revised when the document that created the DTN (ANL-WIS-MD-000027 REV 00) was approved. As a result, the citation to the FEP DTN is out of date and, more importantly, some of the FEP descriptions and justifications have changed. The citations for the FEP DTN will be updated to the most recent version.

TBV-8685. In Table H-1 of the parent document, the citation to *Postclosure Nuclear Safety Design Bases* (ANL-WIS-MD-000024 REV 01) is incorrectly attributed to BSC and has the wrong year identified. The citation will be corrected in this ERD.

TBV-8687. In Table H-1, the citation for *Total System Performance Assessment Model/Analysis for the License Application* (MDL-WIS-PA-000005 REV 00) contains the wrong year. The citation will be corrected in this ERD.

II. Inputs and/or Software

The updates to Appendix H presented below are based on Revision 01 of DTN: MO0706SPAFEPLA.001 [DIRS 185200]. This DTN is qualified product output of ANL-WIS-MD-000027 REV 00.

No software controlled under IM-PRO-003, *Software Management*, is used in the analysis contained in this error resolution document.

III. Impact Evaluation / Changes to the Document

TBV-8672. Several changes are required to address TBV-8672. First, in all cases, the citation to the FEP DTN should be updated to Revision 01 [DIRS 185200]. Thus, the citation to the FEP DTN should be DTN: MO0706SPAFEPLA.001 [DIRS 185200] on the following pages: 1-2, 6-37, 6-42 (Table 6.2-8 footnote), H-6, H-7, H-8, and H-9.

The reference listing in Section 9, page 9-21 should replace the reference listing for number 181613 with the following:

185200 MO0706SPAFEPLA.001. FY 2007 LA FEP List and Screening. Submittal date: 03/05/2008.

Other specific changes are given below to make the document consistent with DTN: MO0706SPAFEPLA.001 [DIRS 185200] (file: *FEP_AMR.doc*).

Table 6.2-8, FEP 2.3.11.01.0A, Precipitation. The FEP description is revised to:

> Precipitation is an important control on the amount of infiltration, flow in the unsaturated zone, seepage into the repository, and groundwater recharge. It transports solutes with it as it flows downward through the subsurface or escapes as runoff. Precipitation influences agricultural practices of the receptor. The amount of precipitation depends on climate.

Table 6.2-8, FEP 2.3.11.02.0A, Surface Runoff and Flooding. The FEP description is revised to:

> Surface water runoff and evapotranspiration are components in the water balance, together with precipitation, infiltration, and change in soil water storage. Surface runoff produces erosion, and can feed washes, arroyos, and impoundments, where flooding may lead to increased recharge. Evapotranspiration removes water from soil and rock by evaporation and transpiration via plant root water uptake.

Table 6.2-8, FEP 2.3.11.03.0A, Infiltration and Recharge. The FEP description is revised to:

> Infiltration into the subsurface provides a boundary condition for groundwater flow in the unsaturated zone. The amount and location of the infiltration influences the amount of seepage entering the drifts; and the amount and location of recharge influences the height of the water table, the hydraulic gradient, and therefore specific discharge. Different sources of infiltration could change the composition of groundwater passing through the repository. Mixing of these waters with other groundwaters could result in mineral precipitation, dissolution, and altered chemical gradients in the subsurface.

The whole of Section H4 is replaced with the text below. Text that has been deleted is marked with strikethrough and added text is underlined.

H4. EVALUATION OF IMPACT ON GROUP 3 PRODUCTS

H4.1 Ventilation Model/Analysis Report (ANL-EBS-MD-000030 REV. 04)

Evaluation—The ventilation model calculates heat-removal efficiency for preclosure ventilation. It does not include effects from latent or sensible heat transfers associated with the presence of water, because these are small compared to air convection, thermal radiation, and solid-conduction in the near-field environment. To verify this model simplification, Section 6.9.1 of this report evaluates an alternative model, whereby latent heat from *in situ* porewater evaporation, and vapor removal by ventilation, contribute significantly to heat removal from the repository. Using a location-specific value of 15.71 mm/yr (rounded) for present-day percolation, and assuming a capture zone of width equal to two drift diameters, the calculation shows that 1.4% of the waste-generated heat could be removed as latent heat by evaporation over a 50 yr period. Even with a higher value of the percolation flux (see Figure H-1 for the uncertainty range) the effect on ventilation is limited to a few percent. The difference in weighted values of present-day flux from the previous flow model compared to the current one (Table H-2) is insignificant to this result. The effect of evaporation is to increase efficiency, which could be compensated by reducing the air flow rate. For these reasons no further calculation of the sensitivity of ventilation efficiency to the local percolation flux is needed.

Ventilation FEPs—Ventilation model results are used to include various FEPs including (DTN: MO0706SPAFEPLA.001 [DIRS ~~181613~~185200]):

- Preclosure Ventilation (1.1.02.02.0A)
- Repository Dryout Due to Waste Heat (2.1.08.03.0A)

- ~~Chemical Characteristics of Water in Drifts (2.1.09.01.0A)~~
- Heat Generation in EBS (2.1.11.01.0A)
- ~~Thermal Effects on Flow in the EBS (2.1.11.09.0A)~~
- Thermally Driven Flow (Convection) in Drifts (2.1.11.09.0C).

No FEP exclusion arguments are directly supported by the ventilation model report, so there are no associated impacts to evaluate.

H4.2 Drift-Scale Coupled Processes (DST and TH Seepage) Models (MDL-NBS-HS-000015 REV. 02)

Evaluation of Flux Values Used—This model report includes a thermal-hydrologic (TH) simulation of the Drift-Scale Test (DST), and a series of simulations and sensitivity analyses that describe the potential for seepage into repository drifts during the thermal period. For the DST, the results provide validation of certain fundamental aspects of TH modeling. For repository seepage, simulation results show that: (1) seepage does not occur when the drift-wall temperature is at or above boiling temperature (96°C); and (2) thermal seepage is less than simulated ambient seepage, because part of the incident percolation flux is diverted by evaporation in the rock. These findings constitute the TSPA implementation of a thermal seepage model; a cutoff temperature of 100°C is used, and ambient seepage fractions and percentages are used to bound thermal seepage (SNL 2007 [DIRS 181244], Section 6.5.2.2). In the following discussion, "thermal seepage model" refers to the implementation of these findings in TSPA, and the underlying simulations and analysis in the subject report.

Base-case percolation flux values of 6, 16, and 25 mm/yr were used in thermal seepage modeling and sensitivity analyses, for the present-day, monsoon, and glacial transition climate states, respectively. Sensitivity analyses increased these values by factors of 5, 10, 20, 40, and 100. The results described above were consistent for all flux conditions, and the effect of greater percolation flux on the thermal regime was to hasten cooling rather than to cause seepage while the drift-wall temperature was above 96°C. Because of this behavior, and the use of an extensive range of flux values for sensitivity analyses, there is no significant impact from the current infiltration and percolation data on this model report.

Evaluation of Hydrologic Property Values Used—The key properties controlling seepage are bulk permeability, capillary strength, and percolation flux. Permeability for the host rock units is based on *in situ* measurements and is not a calibrated parameter (see for example, DTN: LB0610UZDSCP30.001 [DIRS 179180], file: *Calibrated Parameter_R113_30%.doc*). Therefore the permeability description of the host rock is unaffected by changes in the infiltration or percolation flux estimates. The capillary-strength parameter is independently calibrated within the seepage model reports, *Seepage Model for PA Including Drift Collapse* (BSC 2004 [DIRS 167652] and *Seepage Calibration Model and Seepage Testing Data* (BSC 2004 [DIRS 171764]) and is also unaffected by changes in the infiltration or percolation flux estimates (see Section H.3).

Thermal Seepage FEPs—Thermal seepage model results are used to include various FEPs including the following (DTN: MO0706SPAFEPLA.001 [DIRS ~~181613~~185200]):

- Preclosure Ventilation (1.1.02.02.0A)
- Fractures (1.2.02.01.0A)
- ~~Climate Change (1.3.01.00.0A)~~
- Water Influx at the Repository (2.1.08.01.0A)
- Effects of Rapid Influx into the Repository (2.1.08.01.0B)
- Enhanced Influx at the Repository (2.1.08.02.0A)
- Repository Dry-Out Due to Waste Heat (2.1.08.03.0A)
- Repository Resaturation Due to Waste Cooling (2.1.08.11.0A)
- Thermal Effects on Flux in the EBS (2.1.11.09.0A)
- Mechanical Effects of Excavation and Construction in the Near-Field (2.2.01.01.0A)
- Stratigraphy (2.2.03.01.0A)
- Rock Properties of Host Rock and Other Units (2.2.03.02.0A)
- Unsaturated Groundwater Flow in the Geosphere (2.2.07.02.0A)
- Focusing of Unsaturated Flow (Fingers, Weeps) (2.2.07.04.0A)
- Fracture Flow in the UZ (2.2.07.08.0A)
- Matrix Imbibition in the UZ (2.2.07.09.0A)
- Condensation Zone Forms around Drifts (2.2.07.10.0A)
- Resaturation of Geosphere Dryout Zone (2.2.07.11.0A)
- Film Flow into the Repository (2.2.07.18.0A)
- Flow Diversion around Repository Drifts (2.2.07.20.0A)
- Natural Geothermal Effects on Flow in the UZ (2.2.10.03.0B)
- Two-Phase Buoyant Flow/Heat Pipes (2.2.10.10.0A)
- Geosphere Dryout Due to Waste Heat (2.2.10.12.0A)

The thermal seepage model is used to support the exclusion arguments for the following FEPs: ~~determine that dewatering from preclosure activities is insignificant and can be excluded (Changes in Fluid Saturations in the Excavation Disturbed Zone (2.2.01.03.0A). No other FEP exclusion arguments are directly supported by the thermal seepage model report.~~

Gas Generation (Repository Pressurization) (2.1.12.01.0A): The possibility to trap gas under a condensation cap is confined to the thermal period, after which the maximum rock temperatures are below boiling. The effect of increased infiltration as noted above would be to cause more rapid cooling and thus reduce the length to time of the thermal period. Thus there is no impact to the exclusion justification in FEP 2.1.12.01.0A.

Changes in Fluid Saturations in the Excavation Disturbed Zone (2.2.01.03.0A): The thermal seepage model is used to determine that dewatering from preclosure activities is insignificant and can be excluded. There is no impact to the exclusion justification because any effects would be in the post closure period.

Re-Dissolution of Precipitates Directs More Corrosive Fluids to Waste Packages (2.2.08.04.0A): One of the findings in FEP 2.2.08.04.0A is that seepage composition is dilute for conditions when seepage occurs, because relatively large local percolation flux is required to produce seepage. Increased infiltration will not decrease the percolation flux and thus not increase the concentration of the dissolved salts. There is no impact to the exclusion justification.

Repository-Induced Thermal Effects on Flow in the UZ (2.2.10.01.0A): Under an increased infiltration case, the thermal effects may be reduced, or occur for a shorter period of time. There is no impact to the exclusion justification for FEP 2.2.10.01.0A.

Natural Air Flow in the UZ (2.2.10.11.0A): Under an increased infiltration case, the thermal effects may be reduced, or occur for a shorter period of time. There is no impact to the exclusion justification for FEP 2.2.10.11.0A.

No other FEP exclusion arguments are directly supported by the thermal seepage model report.

H4.3 Drift-Scale THM Model (MDL-NBS-HS-000017 REV. 01)

Evaluation—This model report evaluates coupling between thermomechanical and hydrologic responses in the host rock around a repository emplacement drift. The coupled calculations used only one set of percolation values: 6, 16, and 25 mm/yr for the three climate states. The model results show that the effect of mechanical deformation on percolation flux is small, primarily because changes in fracture intrinsic permeability are compensated by changes in relative permeability (BSC 2004 [DIRS 169864], Section 6.6.2). As stated in the report, the precise magnitude of the flux does not affect the conclusions significantly. The base-case flux values used in drift-scale thermal-hydrologic-mechanical (THM) modeling (6, 16, and 25 mm/yr) can be shown to be similar to the current data (e.g., by comparison to the composite values for the three climate states) (Table H-2). This means that the THM model is just as representative of host-rock behavior with the current flux data, as with the previous data. For these reasons the THM model results are still directly relevant and applicable to FEP exclusion arguments.

THM FEPs – The drift-scale THM model describes host-rock responses that are not included in TSPA. The report is cited in the arguments to exclude the following FEPs (DTN: MO0706SPAFEPLA.001 [DIRS ~~181613~~185200]):

- Water Flux at the Repository (2.1.08.01.0A)
- Effects of Subsidence (2.2.06.04.0A)
- Seismic Activity Changes Porosity and Permeability of Rock (2.2.06.01.0A)
- Seismic Activity Changes Porosity and Permeability of Faults (2.2.06.02.0A)
- Seismic Activity Changes Porosity and Permeability of Fractures (2.2.06.02.0B)
- Thermally Induced Stress Changes in the Near-Field (2.2.01.02.0A)
- Radionuclide Transport in the Excavation Disturbed Zone (2.2.01.05.0A)
- Repository-Induced Thermal Effects on Flow in the UZ (2.2.10.01.0A)
- Thermal-Mechanical Stresses Alter Characteristics of Fractures near Repository (2.2.10.04.0A)
- Thermal-Mechanical Stresses Alter Characteristics of Faults near Repository (2.2.10.04.0B)

Many of these exclusion arguments are thermal-mechanical and do not depend on the percolation flux. The effects of THM changes in fracture permeability in the near field on the potential for seepage and radionuclide transport are excluded, based on arguments that do not depend closely on the percolation flux.

H4.4 Mountain-Scale Coupled Processes (TH/THC/THM) Models (MDL-NBS-HS-000007 Rev. 03)

This family of mountain-scale models includes a three-dimensional TH model, a two-dimensional TH profile model, a two-dimensional thermal-hydrologic-chemical (THC) profile model, and a two-dimensional THM profile model. The two-dimensional TH profile model forms the basis of the THM and THC models that consist of all or part of the same profile. As TSPA supporting work, these models are used only in disposition of FEPs (see below). The three-dimensional mountain-scale TH model occupies the same spatial domain as the UZ flow model and uses the same infiltration flux boundary conditions. The average values of net infiltration for this model (Table H-2) are comparable to averages from the current data for the repository footprint (10th percentile), for both surface infiltration and host-rock percolation. However, this model is not used directly in FEP screening and is not discussed further here.

The two-dimensional mountain-scale TH model uses a spatial profile of net infiltration extracted from the previous infiltration data used as a boundary condition for the previous UZ flow model as discussed above. Accordingly, the flux boundary condition is spatially variable. The averages for this profile, for the three climate states, are closely comparable to the weighted composite values for both the previous and current data for the repository footprint (Table H-2). The higher percentiles of the current data include average flux values, which are approximately 3 times the upper limit of the two-dimensional TH model (74.49 versus 28.8 mm/yr; Table H-2). Such conditions tend to quench the thermal-hydrologic response and hasten the return to pre-heating conditions. The same profile boundary condition is used for the two-dimensional mountain-scale THM model. Greater fluxes (e.g., 3 times greater) would not approach the unsaturated hydraulic conductivity of the host rock, even if permeability were decreased as much as a factor of 5 by THM processes (BSC 2005 [DIRS 174101], Section 6.5.12). Thus the finding that mountain-scale THM processes do not affect the vertical percolation flux in the host rock holds for greater values of the flux.

The two-dimensional mountain-scale THC model uses a segment of the two-dimensional profile discussed above. This is a north-south profile, and lateral diversion at interfaces between stratigraphic units is not significant, so percolation is predominantly downward in the model. The average fluxes along the profile (ranging up to 106 mm/yr in the glacial transition climate) are roughly comparable to the averages for the current 50th and 90th percentile flux fields for all three climate states (Table H-3). As such, the two-dimensional mountain-scale THC model does not exhibit significant diversion effects and represents a relatively wet profile, whether compared to the previous or current infiltration/percolation data sets.

Mountain-Scale FEPs—The mountain-scale coupled-process models are used to support inclusion of one FEP (1.1.07.00.0A) and exclusion of six FEPs as discussed below (DTN: MO0706SPAFEPLA.001 [DIRS ~~181613~~185200]):

- **Repository-Induced Thermal Effects on Flow in the UZ** (2.2.10.01.0A) The mountain-scale two-dimensional TH model shows that the limited extent of flow redistribution found at the mountain scale is consistent with drift-scale results (BSC 2005 [DIRS 174101], Section 6.5.13).

- **Mineralogic Dehydration Reactions** (2.2.10.14.0A) Results from the two-dimensional mountain-scale TH model suggests that temperature at the base of the TSw will remain below 77°C in the southern portion of the repository, and below 74°C in the northern portion (BSC 2005 [DIRS 174101], Section 6.2). Therefore the temperature changes induced by the repository will not cause significant zeolite dehydration or volume changes in the zeolitic rock (DTN: MO0706SPAFEPLA.001 [DIRS 181613]).

- **Thermo-Chemical Alteration of the Calico Hills Unit** (2.2.10.07.0A) ~~Trends in the two-dimensional mountain-scale THC model results, particularly in the variation of chloride and pH, are similar to drift-scale simulations. Variations in chloride are driven mainly by evaporation and are found to return to near-ambient values upon rewetting (BSC 2005 [DIRS 174101], Section 6.4.3.3.2).~~ Although the THC Mountain Scale Model [DIRS 174101] is cited in the exclusion justification, it is not used as a basis for exclusion. The main reason the THC mountain-scale model results are not used in the FEP exclusion argument is because the dissolution/precipitation rates in that model were 2-4 orders of magnitude larger than the THC seepage model (SNL 2007 [DIRS 177404]), which are more representative of data. Thus, the fact that the "old" infiltration rates were used in the older mountain-scale THC models is irrelevant to the screening justifications in this FEP.

- **Thermo-Chemical Alteration of the Topopah Spring Basal Vitrophyre** (2.2.10.09.0A) The lack of impact on this FEP from the THC Mountain Scale Model [DIRS 174101] is the same as above. The THC Mountain Scale Model [DIRS 174101] is not used as the basis for justification. Thus, the use of older infiltration rates in the THC Mountain Scale Model does not alter the screening justification.

- ~~**Geochemical Interactions and Evolution in the UZ** (2.2.08.03.0B) Fluctuations in host-rock water composition during the thermal period will be relatively short-lived (much less than 10,000 yr) and of limited magnitude compared to the existing ambient variability of *in situ* water composition. Trends in two-dimensional mountain-scale THC model results, particularly in the variation of chloride and pH, are similar to drift-scale simulations (BSC 2005 [DIRS 174101], Section 6.4.3.3.2)~~

- **Thermal-Mechanical Stresses Alter Characteristics of Rocks Above and Below the Repository** (2.2.10.05.0A) THM-induced changes in the two-dimensional mountain-scale THM model hydrological properties have no significant impact on the vertical percolation flux through the repository horizon (BSC 2005 [DIRS 174101, Sections 6.5.10 to 6.5.14).

- **Repository-Induced Thermal Effects on Flow in the SZ** (2.2.10.13.0A) The potential reduced impact of Mountain Scale TH processes under an increased infiltration case will not alter the exclusion justification for FEP 2.2.10.13.0A.

These arguments do not depend closely on the percolation flux, for the various reasons discussed above. No further impact evaluation is needed to confirm the applicability of documented FEP screening arguments based on the mountain-scale models, developed using the previous (INFIL-based) infiltration and percolation data.

TBV-8685: The citation to the postclosure nuclear safety design bases document (ANL-WIS-MD-000024 REV 01) incorrectly identifies it as a 2007 document, but it should be 2008. The reference in Table H-1 should be changed from BSC 2006 [DIRS 177464] to SNL 2008 [DIRS 177464]. On page 9-11, the reference listing for DIRS 177464 should be revised to point to 2008 as the year, and the document numbers ACC: DOC.20080226.0002 and DOC.20080314.0004 should also be added to the listing.

TBV-8687: The citation to the TSPA document (MDL-WIS-PA-000005 REV 00) has an incorrect year. On page 9-12, the year of DIRS entry 178871 should be changed to 2008 and the document record number ACC: DOC.20080204.0003 should be added to the reference listing.

In Table H-1, the citation SNL 2007 [DIRS 178871] should be SNL 2008 [DIRS 178871].

IV. Impact Analysis and Conclusions

TBV-8672: The changes in this ERD replaced the Revision 00 version of the FEP DTN with the Revision 01 version and revised the text to be consistent with the cited source. The changes provide consistency with the cited reference but do not alter the output DTNs or conclusions of MDL-NBS-HS-000006 REV 03 AD 01. Only four documents use MDL-NBS-HS-000006 REV 03 or MDL-NBS-HS-000006 REV 03 AD 01 as direct input: the Safety Analysis Report, the FEPs report (ANL-WIS-MD-0000027 REV 00), the TSPA report (MDL-WIS-PA-000005 REV 00), and the postclosure nuclear safety design bases document (ANL-WIS-MD-000024 REV 01). The major changes occur in Appendix H and none of these documents reference that appendix. Because no changes to results or conclusions resulted from the changes in this ERD, there are no impacts to downstream documents.

TBV-8685: The minor editorial changes are a result of TBV-8685 do not alter the conclusions or outputs of MDL-NBS-HS-000006 REV 03 AD 01. As above, there are no impacts to downstream documents.

TBV-8687: The minor editorial changes are a result of TBV-8687 do not alter the conclusions or outputs of MDL-NBS-HS-000006 REV 03 AD 01. As above, there are no impacts to downstream documents.